Evaluation of Traffic Safety Facilities for Reducing Traffic Accidents on the Gyeongbu Expressway

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ABSTRACT

With raising social concern on traffic safety, business on improving traffic safety including provision of traffic safety facilities has been continued to reduce accidents on national highways and expressways. On certain Gyeongbu expressways where the scale of accidents is particularly large, continuous investment on traffic safety facilities has done. However, for now, appropriate criterions of prevention of accidents and effective execution of public budget regarding certain traffic safety facilities at particular points are hard to find. Thus, the purpose of this study is to establish the most effective system for not only efficient execution of limited public budget for new provision of traffic safety facilities but also minimization of social cost of occurrences of accidents by setting up exact DB of existing traffic safety facilities and performing analysis on before and after the improvement of these facilities using the DB.

Thus, this study will evaluate the effect of the traffic safety facilities on roadways, especially the Gyeongbu Expressway where there is a high volume of traffic. In addition, a cost-benefit analysis and an AHP analysis will also be performed to evaluate the general effect of traffic safety facilitieson expressways.

1. INTRODUCTION

Background and purpose

With the increase in social attention in traffic safety, the investment in and related projects regarding traffic safety facilities on expressways continues to rise, focusing on the Gyeongbu Expressway. In order to effectively spend a limited budget, it is necessary to systematically evaluate the effect of the current traffic safety facilities installed on expressways and construct the related infrastructure. Thus, this study will evaluate the effect of the traffic safety facilities on roadways, especially the Gyeongbu Expressway where there is a high volume of traffic.

Scope

This study will build a DB of the traffic safety facilities on expressways; which is generally linked with the data on traffic accidents, the installation history of traffic safety facilities, geometric structures, and an assessment of the volume of traffic for the systematic evaluation of the effect of the traffic safety facilities on the Gyeongbu Expressway. In addition, a cost-benefit analysis and an AHP analysis will also be performed to evaluate the general effect of traffic safety facilities on expressways.

○ Analysis of the effect before and after installing traffic safety facilities on the Gyeongbu Expressway
○ Cost-benefit analysis of the effect of installing traffic safety facilities on the Gyeongbu Expressway

2. LITERATURE REVIEW

Definition of traffic safety facilities

Traffic safety facilities are composed of following items:

○ Safety facilities for traffic management: Traffic safety marks, road signs, pavement signs, etc.
○ Safety facilities for protection: Guard fences, collision absorption systems, emergency escape ramps, etc.
○ Safety facilities for better visibility: Delineation systems, lighting systems, etc.
○ Other safety facilities: Skid-resistance pavement, rumble strips (audio tactile profiled markings), the prevention of falling rocks, and automated speed enforcement cameras, etc.

Domestic and overseas cases

In domestic studies, for example, “The work manual of the project for handling areas where traffic accidents frequently occur (2002)”, which was conducted by the Ministry of Construction and Transportation, shows the decrease in traffic accidents following the installation of traffic safety facilities for each road type. On highways and provincial roads, installing median strips is the best way to reduce traffic accidents. In the case of metro-city, city, and county roads where median strips cannot be installed, installing reboundable delineators is the suitable alternative. The Samsung Traffic Safety Research Institute (2004) analyzed the effect of reducing traffic accidents for each accident type on some highways in Jeollabukdo and Gangwondo. According to the result, in the case of head-on collision accidents, the installation of median strips largely decreases traffic accidents. In the case of rear-end collisions; skid-resistance pavement hugely reduces traffic accidents.

In overseas studies, for example, a study conducted by the FHWA in 1978 shows the decrease in the number of traffic accidents and their victims for each proposal. According to the research, skid-resistance pavement (grooving) is the best way (48%) to reduce the number of traffic accidents. Installing or improving median strips is the best way (91%) to decrease the number of traffic accident victims. In addition, “The Annual Report on Highway Safety Improvement Programs” conducted by the FHWA in 1991 proposes the B/C analysis result on the effect of each project for improving safety on roads. According to the report, installing lighting is the best way to secure road safety, followed by traffic signs, median strips, and the enhancement of bridge rails. Furthermore, each country performs an evaluation of the effects of its traffic safety facilities on a regular basis.

3. ANALYSIS OF THE TRAFFIC SAFETY FACILITIES ON THE GYEONGBU EXPRESSWAY

The scope of constructing a DB on the traffic safety facilities

Contents scope

○ Data on traffic accidents (2000~2007)
○ Data on the installation status and history of the traffic safety facilities (2000~2005)
○ Data on the AADT (Average Annual Daily Traffic) for each year and area (2002~2007)

Time/Spatial scope

○ 1994~2007 the materials of the Gyeongbu Expressway being used as of 2007

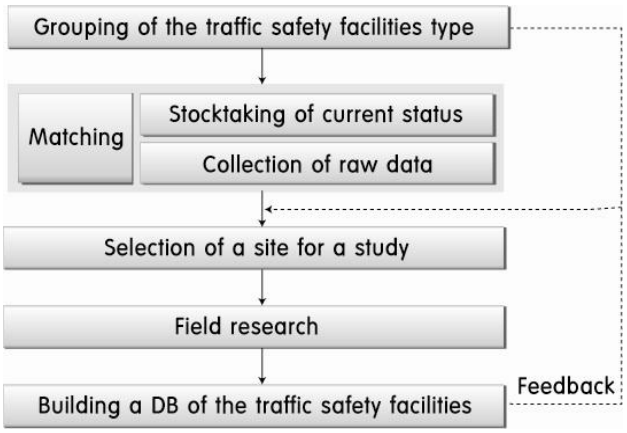

Figure 1. The procedure of building a DB of the traffic safety facilities

Construction of historical material

An historical DB of all expressways based on the amount of traffic accidents per year and the history of installing traffic safety facilities will be constructed. Status analysis is only applied to the Gyeongbu Expressway.

Table 1. Type of DB on the traffic safety facilities

No.	Data on traffic safety facilities								Data on traffic accidents								
	Lane	Direc -tion	Starting point	Termin us	Length (km)	year of establish -ment	Sort facilities	Cost (thousand won)	point	year	Day	Time	class	deaths	injured	Accident cause	Main cause
001-009	Gyeong -bu	Busan	56.2	58.2	2	2002	Speed camera	9,258	56.2	2004	3-16	4:40	C	0	0	driver negligence	doze off at the wheel
001-011	Gyeong -bu	Busan	68.8	69.9	1.1	2003	Lighting	55,000	68.8	2001	5-17	12:45	C	0	0	driver negligence	doze off at the wheel

Traffic accidents on the Gyeongbu Expressway

The number of traffic accidents

In terms of the number of traffic accidents on the Gyeongbu Expressway, it decreased from 1,288 in 2000 to 548 in 2007, and by 11.5% annually.

Table 2. The number of traffic accidents on the Gyeongbu Expressway

Lane	The number of traffic accidents/Year								Compound annual growth rate (%)
	2000	2001	2002	2003	2004	2005	2006	2007	
Gyeong-bu	1,288	1,115	996	918	762	598	555	548	△ 11.5

source) 2007 Traffic Accident Statistics on Expressway, Korea Highway Corporation, 2008.4

The number of traffic accident victims

In terms of the number of traffic accident victims on the Gyeongbu Expressway, it decreased from 1,012 in 2000 to 315 in 2007, and by 15.4% annually.

Table 3. The number of traffic accident victims on the Gyeongbu Expressway

Lane	The number of fatalities (person/year)																Compound annual growth rate (%)	
	2000		2001		2002		2003		2004		2005		2006		2007			
	injured	death	injured	death	injured	death	injured	death	injured	death	injured	death	injured	death	injured	death	injured	death
Gyeong-bu	1,012	204	743	156	532	126	403	97	374	101	240	62	240	82	315	77	△15.4	△13.0

source) 2007 Traffic Accident Statistics on Expressway, Korea Highway Corporation, 2008.4

Traffic accidents in the areas where traffic safety facilities have been installed/enhanced on the Gyeongbu Expressway

This study identifies the characteristics of each traffic safety facility and sets the effect zone as 1 km from the area where the traffic safety facility is constructed/improved in order to increase the analytical reliability of this study. In the case of the rumble strip, guard fence, and skid-resistance pavement, an effect zone is not set because these methods are effective only in the exact areas where the traffic safety facilities are installed/enhanced. In addition, taking into consideration the characteristics of each safety facility, in the case of lighting, analysis is done at only at night. In the case of the collision absorption system, the traffic volume both on-ramp and off-ramp is analyzed. On all expressways the number of traffic safety facilities that are available to be analyzed, is 9. However, this study was done on the Gyeongbu Expressway, and the delineation systems and collision absorption systems, which number less than 3, have been excluded.

The relationship between traffic accidents and traffic safety facilities on expressways has been analyzed using data from two years before and after the year when the traffic safety facilities were installed, and it verifies the significance of the analysis.

Analysis of traffic accidents for each facility

1) The number of traffic accidents

The most-effective traffic safety facilities for decreasing traffic accidents on expressways are traffic safety marks (85.7%), lighting (night) (62.5%), and rumble strips (55.0%). Installing/enhancing traffic safety facilities decreases traffic accidents

Table 4. The number of traffic accidents in areas where traffic safety facilities have been installed/enhanced

Traffic safety facilities	The number of traffic accidents/2year		Growth rate (%)
	Before	After	
Traffic safety sign	21	3	△ 85.7
Rumble strip	40	18	△ 55.0
Crash barrier	27	18	△ 33.3
Speed camera	169	108	△ 36.1
Nonskid pavement	17	16	△ 5.9
Lighting (night)	8	3	△ 62.5

2) Traffic accident rates

The traffic safety facilities, that highly decrease the number of traffic accidents at the rate of a million vehicles/km, are traffic safety marks (85.7%) and rumble strips (68.0%). The traffic accident rate falls after installing/enhancing these facilities. However, in terms of skid-resistance pavement, the number of traffic accidents decreases, but the traffic accident rate increases.

Table 5. The traffic accident rate in areas where traffic safety facilities have been installed/enhanced

Traffic safety facilities	Before (The number of traffic accidents/2year)		After (The number of traffic accidents/2year)		Growth rate (%)	
	The number of traffic accidents /million car	The number of traffic accidents /million car-km	The number of traffic accidents /million car	The number of traffic accidents /million car-km	The number of traffic accidents /million car	The number of traffic accidents /million car-km
Traffic safety sign	0.0809	0.0809	0.0111	0.0111	△ 86.3	△ 86.3
Rumble strip	0.0492	0.0479	0.0157	0.0115	△ 68.0	△ 76.0
Crash barrier	0.0603	0.0954	0.0306	0.0507	△ 49.3	△ 46.9
Speed camera	0.0752	0.1481	0.0544	0.1072	△ 27.7	△ 27.7
Nonskid pavement	0.0882	0.1780	0.1069	0.2152	21.3	20.9
Lighting (night)	0.0569	0.0870	0.0243	0.0380	△ 57.4	△ 56.4

3) The number of traffic injuries

The traffic safety facilities, that highly decrease the number of traffic accidents on expressways, are traffic safety marks (85.7%), lighting (night) (62.5%) and rumble strips (55.0%). The traffic accident rate falls after installing/enhancing these traffic safety facilities.

Table 6. The number of traffic injuries in areas where traffic safety facilities have been installed/enhanced.

Traffic safety facilities	The number of injured person/2year		Growth rate (%)
	Before	After	
Crash barrier	18	5	△ 72.2
Speed camera	88	54	△ 38.6
Nonskid pavement	6	3	△ 50.0
Lighting (night)	2	1	△ 50.0

4) Traffic injury rates

The traffic safety facilities, that highly decrease the number of traffic injuries at the rate of a million vehicles/km, are the guard fence (78.5%) and lighting (night) (42.7%). The traffic injury rate generally reduces after installing/enhancing these traffic safety facilities.

Table 7. The traffic injury rate in areas where traffic safety facilities have been installed/enhanced

Traffic safety facilities	Before (The number of injured person /2year)		After (The number of injured person /2year)		Growth rate (%)	
	The number of injured person /million car	The number of injured person /million car-km	The number of injured person /million car	The number of injured person /million car-km	The number of injured person /million car	The number of injured person /million car-km
Crash barrier	0.0513	0.0604	0.0046	0.0130	△ 91.0	△ 78.5
Speed camera	0.0359	0.0709	0.0256	0.0504	△ 28.6	△ 28.9
Nonskid pavement	0.0370	0.0715	0.0211	0.0466	△ 42.8	△ 34.8
Lighting (night)	0.0154	0.0219	0.0063	0.0125	△ 59.4	△ 42.7

5) The number of traffic fatalities

The traffic safety facility, that highly decreases the number of traffic fatalities, is the rumble strip (66.7%). In the case of the automated speed enforcement camera, the number of traffic injuries did not

change (it was 15 before the installation/enhancement and 15 after the installation/enhancement).

Table 8. The number of traffic fatalities in areas where traffic safety facilities have been installed/enhanced

Traffic safety facilities	The number of dead person/2year		Growth rate (%)
	Before	After	
Rumble strip	3	1	△ 66.7
Speed camera	15	15	△ 0.0

6) Traffic fatality rates

The traffic safety facility, that highly decreases the number of traffic fatalities at the rate of a million vehicles/km, is the rumble strip (86.6%). In the case of the automated speed enforcement camera, the number of fatalities did not change, but the number of fatalities at the rate of a million vehicles/km decreases by 9.1%.

Table 9. The traffic fatality rate in areas where traffic safety facilities have been installed/enhanced

Traffic safety facilities	Before (The number of injured person /2year)		After (The number of injured person /2year)		Growth rate (%)	
	The number of injured person /million car	The number of injured person /million car-km	The number of injured person /million car	The number of injured person /million car-km	The number of injured person /million car	The number of injured person /million car-km
Rumble strip	0.0049	0.0061	0.0020	0.0008	△ 58.5	△ 86.6
Speed camera	0.0088	0.0170	0.0079	0.0154	△ 9.7	△ 9.1

4. ANALYSIS OF ECONOMIC EFFICIENCY

The selection of the traffic safety facilities to be analyzed

The traffic safety facilities analyzed when taking economic efficiency into consideration are described in Table 9. The reason that only four traffic safety facilities were analyzed is that there is not much data on traffic safety marks, resulting in a low analytical reliability.

Table 10. The traffic safety facilities selected when economic efficiency was analyzed

Category	Traffic safety facilities
Total	Traffic safety sign , Rumble strip, Crash barrier, Speed camera, Nonskid pavement, Lighting (night)
Selected	Rumble strip, Crash barrier, Speed camera, Lighting (night)

Estimation of cost

To estimate the cost of installing/enhancing the traffic safety facilities on expressways, the unit price list of the traffic safety facilities of the Korea Expressway Corporation was applied. The unit price of installing /improving traffic safety facilities is calculated as of 2005. In the case of the automated speed enforcement camera and the collision absorption system, which are not described in the unit price list, the list, "Price information on commodities for government procurement", of the Public Procurement Service was used, and the cost estimation result is described in Table 11.

Table 11. The cost estimation of installing/enhancing traffic safety facilities (Units: 10 thousand won)

Category	materials	labor cost	In addition	setup cost
Rumble strip	1,130	1,461	1,547	4,139
Crash barrier	16,188	12,058	454	28,700
Speed camera	29,040	1,171	344	30,554
Lighting (night)	8,866	5,923	355	15,144
Total cost	55,225	20,613	2,700	78,537

Estimation of the benefits of the decrease in traffic accidents

In order to estimate the benefits of the decrease in traffic accidents following the installation/enhancement of traffic safety facilities on expressways, quantitative analysis of the cost of each traffic accident was applied. This study applies the cost of the traffic accidents including the PGS cost (including the physical/mental anguish cost); information on the costs is described in Table 12.

Table 12. The cost of each traffic accident (Units: 10 thousand won/traffic accident)

Category	Accident cost (excluding PGS)	Accident cost (including PGS)
per the accident	2,474	3,966

source) 2005 A Study on Estimation of Cost Occurred by Traffic Accident, The Korea Transportation Institute, 2006.

Based on the traffic accident costs described in Table 12, this study calculates the benefit of the decrease in traffic accidents as a result of the traffic safety facilities.

Table 13. The benefit of the decrease in traffic accidents as a result of the traffic safety facilities (Units: 10 thousand won/traffic accident)

Traffic safety facilities	Before (A)	After (B)	Benefit (A-B)
Rumble strip	158,640	71,388	87,252
Crash barrier	107,082	71,388	35,694
Speed camera	670,254	428,328	241,926
Lighting (night)	31,728	11,898	19,830
Total	967,704	583,002	384,702

Analysis results

Based on the results of the cost-benefit calculation for installing/improving traffic safety facilities on expressways, this study performs a cost-benefit analysis in order to analyze the effect of installing/improving the facilities.

Table 14. The results of the analysis of economic effectiveness (Units: 10 thousand won)

Traffic safety facilities	B/C ratio		
	Benefit (B)	Cost (C)	Benefit/Cost (B/C)
Rumble strip	87,252	4,139	21.1
Crash barrier	35,694	28,700	1.2
Speed camera	241,926	30,554	7.9
Lighting (night)	19,830	15,144	1.3
Total	384,702	78,537	4.9

According to the results of the cost-benefit analysis, the B/C value is generally larger than 1, and the traffic safety facilities that lead to the best results are the rumble strip (21.1) and the automated speed enforcement camera (7.9). The reason that the rumble strip has the highest value is that the cost of installing/improving the rumble strip is less than that of other traffic safety facilities. It has been determined that the project of installing/enhancing the traffic safety facilities on the Gyeongbu Expressway has been effective.

5. CONCLUSION

According to the analysis of the traffic accidents that occurred on the Gyeongbu Expressway, after performing the project of installing/improving the traffic safety facilities, traffic accidents and the traffic accident rate generally decrease. According to the analysis of the traffic injuries and fatalities, as with the analysis of the traffic accidents, the number also generally decreases. According to the analysis of the economic effectiveness of the Gyeongbu Expressway, the B/C value is generally larger than 1, and the installation/improvement of traffic safety facilities is deemed effective.

Since the project of installing/enhancing traffic safety facilities on the Gyeongbu Expressway has been effective, it can be expected that continuous investment in the installation/enhancement of the traffic safety facilities on expressways will decrease traffic accidents and their victims

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